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August 1997

US Army Corps of Engineers
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Strategic Environmental Research and Development Program

Species Profile: Flatwoods Salamander (*Ambystoma cingulatum*) on Military Installations in the Southeastern United States

by John G. Palis

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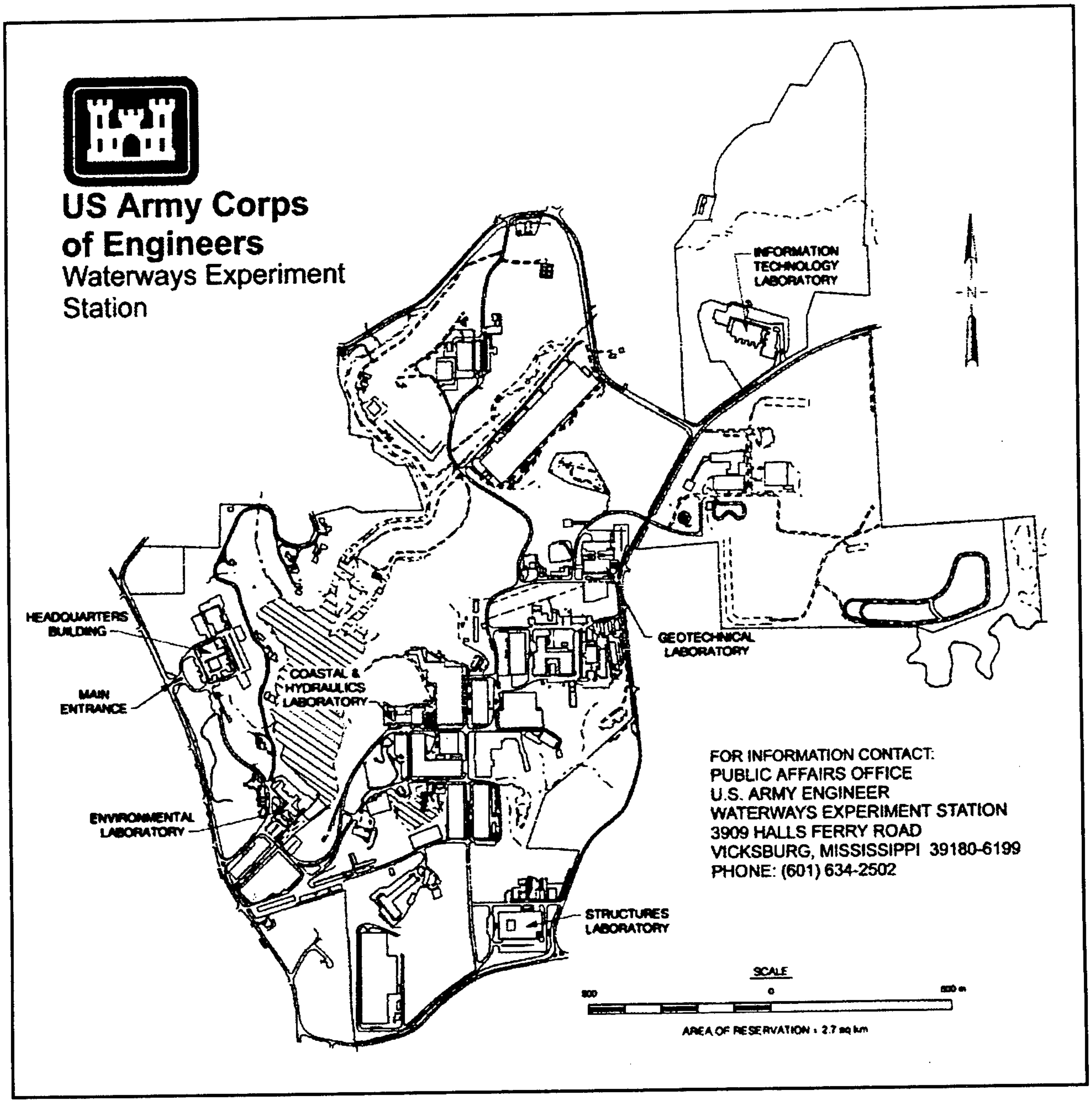

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Preface

The work described herein was authorized by the Strategic Environmental Research and Development Program (SERDP), Washington, DC. The work was performed under the SERDP study entitled "Regional Guidelines for Managing Threatened and Endangered Species Habitats." Dr. John Harrison was Executive Director, SERDP.

This report was prepared by Mr. John G. Palis, Jonesboro, IL. Portions of this report were taken from The Nature Conservancy's Element Stewardship Abstract (ESA) titled "Species Stewardship Summary; *Ambystoma cingulatum*" prepared by Mr. John G. Palis. The ESA was prepared under contract with the U.S. Army Construction Engineering Research Laboratories (CERL), Natural Resources Division, Champaign, IL, for a document titled "Integrated Endangered Species Management Recommendations for Army Installations in the Southeastern United States: Assessment of Army-Wide Guidelines for the Red-Cockaded Woodpecker on Associated Endangered, Threatened, and Candidate Species."

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This report was prepared under the general supervision of Dr. Michael F. Passmore, Chief, Stewardship Branch, Natural Resources Division (NRD), EL; Dr. Dave Tazik, Chief, NRD; and Dr. John Harrison, Director, EL.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES.

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Species Profile: Flatwoods Salamander
(Ambystoma cingulatum)

Flatwoods Salamander; photo by John G. Palis

Taxonomy

Class	Amphibia
Order	Caudata
Family	Ambystomatidae
Genus/species	*Ambystoma cingulatum*
Other Common Names	None known

Description

The flatwoods salamander is a moderately sized (up to 76-mm (3-in.) snout-vent length, 135-mm (5.3-in.) total length; Palis 1996), slender salamander with a relatively small, pointed head and stout tail, weighing from 4.5 to 10.5 g (0.16 to 0.37 oz), adult male and gravid female, respectively (Palis 1996). The body is black to chocolate-black with fine, irregular, light gray lines that form a netlike or crossbanded pattern across the back. In some individuals the gray pigment is widely scattered and "lichenlike." Melanistic, uniformly black individuals are occasionally encountered (Carr 1940). The belly is black to chocolate-black with a scattering of gray spots or flecks.

Although sexual dimorphism is not pronounced in flatwoods salamanders, males can be distinguished from females during the breeding season by their slightly swollen cloaca. In addition, mature gravid females are heavier and more robust than males at this time (Palis 1996).

The broad-headed, boldly striped pond-type larva can attain a snout-vent length of 47 mm (1.8 in.) and total length of 96 mm (3.8 in.) before metamorphosis (Palis 1996). The striping pattern, from mid-dorsum down the sides, includes a pale tan mid-dorsal stripe, grayish-black dorsolateral stripe, pale cream mid-lateral stripe, blue-black lateral stripe, and pale yellow ventrolateral stripe. A black stripe extends from the snout, through the eyes, to the base of the gills. A second dark stripe, extending along the upper jaw, is typically present, as well.

Similar Species

Adult flatwoods salamanders may be confused with the slimy salamander (*Plethodon grobmani*), small-mouth salamander (*Ambystoma texanum*), or Mabee's salamander (*Ambystoma mabeei*). Slimy salamanders are readily distinguished by the presence of a small groove (nasolabial groove) from the nostril to upper lip (absent in all *Ambystoma*). The range of the small-mouth salamander overlaps that of the flatwoods salamander in extreme southwestern Alabama. Small-mouth salamanders have a very short, rounded snout and, in Alabama, are brown or dark gray with lichenlike light blotches (Mount 1975). In South Carolina, flatwoods and Mabee's salamanders have been observed breeding in the same wetland (Anderson and Williamson 1976). The body of Mabee's salamander is dark brown or black with pale specks that are concentrated along the sides.

Although the flatwoods salamander larval pattern is distinctive, two other *Ambystoma* larvae may appear similar to the untrained eye. Both flatwoods and Mabee's salamander larvae have a light mid-lateral stripe between two dark lateral stripes. However, unlike the continuous lateral stripes of the flatwoods salamander, those of Mabee's salamander are broken into blotches. In addition, the stripe extending from the snout to the gills in *A. mabeei* is diffuse and indistinct, and the upper lip stripe is replaced by a series of spots (Hardy and Olmon 1974). Larval mole salamanders (*A. talpoideum*) may have an indistinct, light mid-lateral stripe, but are readily distinguished from *A. cingulatum* larvae by the presence of a dark mid-ventral stripe and dark dorsal crossbands (Palis 1996). The light mid-lateral stripe of larval *A. cingulatum* is retained by metamorphs through their first year (Palis 1997). It is best observed by shining a bright light through the body.

Status

Legal designation

Federal. The U.S. Fish and Wildlife Service considered the flatwoods salamander a candidate (C2) species for listing; it is now unofficially considered a species of concern.

State. The flatwoods salamander is state listed as rare in Georgia (Palis 1996) and endangered in South Carolina (Means et al. 1996).

Distribution and numbers

The flatwoods salamander inhabits the lower Southeastern Coastal Plain from southern South Carolina, southward to Marion County, Florida, and westward through Georgia to extreme southwestern Alabama (Conant and Collins 1991) (Figure 1). In Georgia, the species occurs mainly in the lower coastal plain, but is also found in

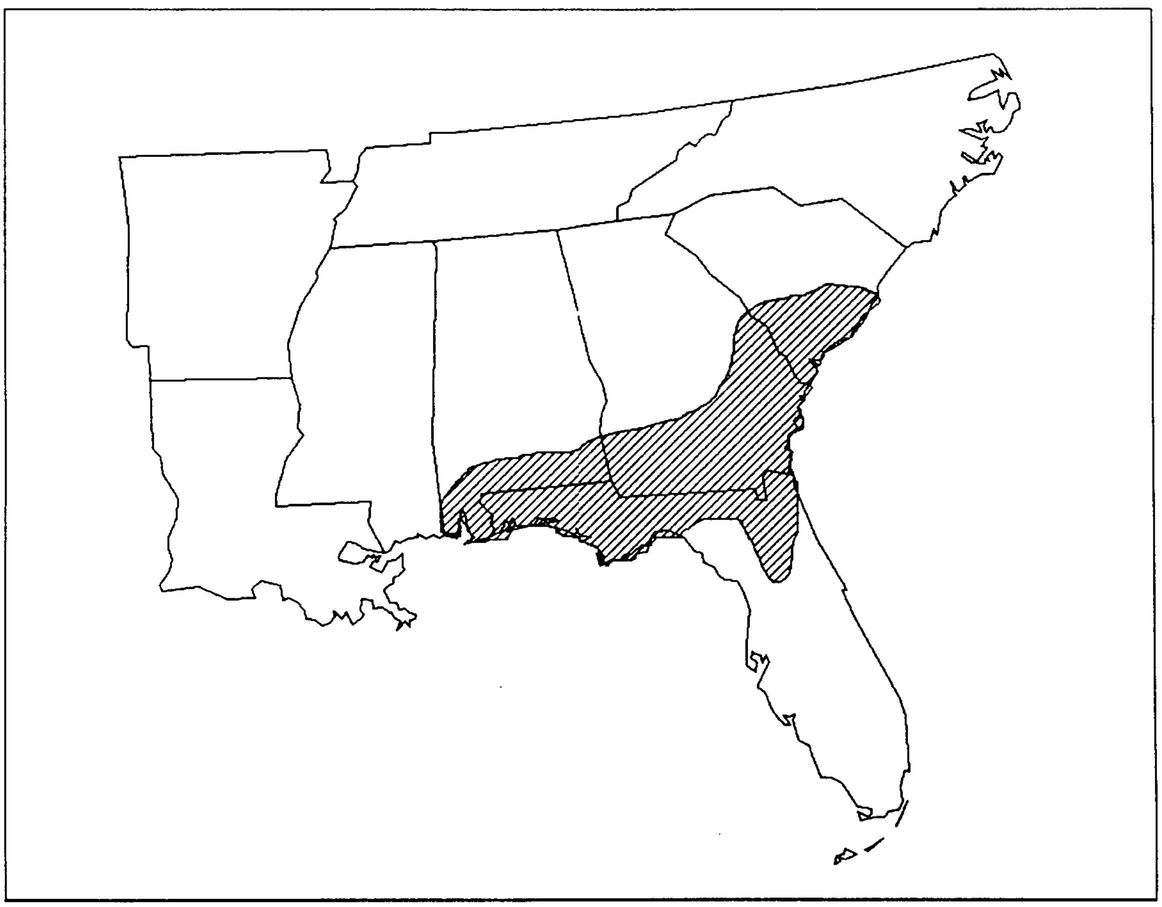

Figure 1. Approximate distribution of flatwoods salamanders in the southeastern United States (Mount 1975, Ashton 1992).

coastal plain; however, it is absent from the area between the Ocmulgee and Ohoopee rivers. The inclusion of North Carolina and Mississippi on old range maps is apparently the result of misidentification of larval specimens (Hardy and Olmon 1974; P. Moler, Personal Communication, 1995). No subspecies are recognized.

Most secure populations of flatwoods salamanders appear to be in Florida, where 32 extant populations are known to occur west of the Suwannee River (erroneously reported as 37 in Palis (1996)). The only known extant Florida population east of the Suwannee River is found in the Osceola National Forest (Palis 1996). In Georgia, extant populations of flatwoods salamanders occur at opposite ends of the state. Flatwoods salamanders presently exist at Fort Stewart and the Naval Bombing Range in southeastern Georgia (D. Stevenson, Personal Communication, 1995) and Ichauway Plantation in southwestern Georgia (Palis 1996). Flatwoods salamanders have not been observed in Alabama since 1981 (J. Godwin, Personal Communication, 1995). Although not observed in South Carolina between 1991 and 1994, flatwoods salamanders were confirmed as still using a historic breeding site in October 1995 (S. Bennett, Personal Communication, 1996).

Military installations

See Table 1.

Table 1
Status of the Flatwoods Salamander on Military Installations in the Southeastern United States

State	Installation	Status on Installation
FL	Eglin Air Force Base (AFB)	Documented in 25 wetlands. Three breeding populations were identified and consisted of 1, 3, and 21 breeding sites (Palis 1995a).
	Tyndall AFB	Poor Potential (Knight et al. 1994).
GA	Fort Stewart	Documented (5 populations); 20 wetlands were identified as breeding sites (The Nature Conservancy 1995).

Life History and Ecology

Behavior

Post-larval flatwoods salamanders are fossorial and occupy burrows (Goin 1950, Neill 1951, Mount 1975, Ashton 1992). They have been tracked moving as far as 1.7 km (1.1 miles) from a breeding site (Ashton 1992). Preliminary data suggest that flatwoods salamanders have an activity range of approximately 1,500 m^2 (0.4 acres) (Ashton 1992). During the breeding season (October through December), adults leave their subterranean retreats and migrate to breeding sites during rains associated with passing cold fronts (Means 1972, Anderson and Williamson 1976, Palis 1997). Despite this activity at the surface, adult flatwoods salamanders are rarely encountered under cover objects at or near breeding sites (Palis 1997). Small numbers of post-larval salamanders continue to be active on the surface during the winter months (Palis 1997). Metamorphs emigrate from their natal ponds during the months of March and April (Palis 1996). Presumably, post-larval flatwoods salamanders remain underground during the lightning-fire season (May through September).

Reproduction and development

Reproduction occurs between early October and January (Means 1972, Anderson and Williamson 1976, Ashton 1992, Palis 1997). Females lay up to 225 eggs (Ashton 1992), with larger individuals producing more eggs than smaller ones (Anderson and Williamson 1976). Before breeding sites fill with water, eggs are deposited singly or in small groups on the ground beneath leaf litter, under logs and *Sphagnum* mats, at the base of grasses, shrubs, or trees, or at the entrance to crayfish (*Procambarus* spp.) burrows (Anderson and Williamson 1976). In wetlands that fill incrementally, eggs are deposited at the edge amid graminaceous vegetation (Palis 1996). Eggs are laid terrestrially before depressions fill with water and hatch upon inundation (Anderson and Williamson 1976). The eggs develop to hatching size within 3 weeks, but do not hatch until inundated (Anderson and Williamson 1976). Larvae hide amid inundated graminaceous vegetation by day and enter the water column at night (Palis 1995b). Larvae grow at a rate of 1.69 to 2.54 mm (0.07 to 0.10 in.)/ week (Palis 1995b) and metamorphose at 36- to 47-mm (1.4- to 1.8-in.) snout-vent length (Personal Observation). The larval period lasts for three to four and one-half months, with metamorphosis typically occurring in March and April (Means 1986, Palis 1995b). In captivity, flatwoods salamanders can attain adult size within 1 year (Means 1972). Preliminary field data, however, suggest that flatwoods salamanders in the wild do not attain full size until their third or fourth year (Palis 1997). Although not much bigger than metamorphs, males attain sexual maturity in their first year (Palis 1997). Females, however, do not mature sexually until at least 2 years of age (Palis 1997). Adults have been tracked moving as far as 1.7 km (1.1 miles) from breeding sites (Ashton 1992).

Food habits

Little information is available regarding the food habits of flatwoods salamanders. Adults likely eat a variety of terrestrial invertebrates (The Nature Conservancy (TNC) 1995). Goin (1950) found earthworm remains in the stomachs of adults he dissected. The food habits of larvae have not been studied, but they undoubtedly prey upon smaller animals (e.g., aquatic invertebrates) as do other larval *Ambystoma*.

Habitat Requirements

Flatwoods salamander habitat generally includes fire-maintained, open-canopied longleaf pine (*Pinus palustris*) and slash pine (*P. elliottii*) savannas and flatwoods of the southeastern coastal plain.

Breeding habitat

Breeding sites include pine flatwoods depressions, including cypress- or blackgum-dominated swamps, roadside ditches (Anderson and Williamson 1976, Palis 1996), and borrow pits (D. Stevenson, Personal Communication, 1995). A breeding site typically is encircled by a wiregrass-dominated graminaceous ecotone, and the floor is riddled with the burrows of crayfish. These wetlands often harbor fishes, of which the most typical species are pygmy sunfishes (*Elassoma* spp.), mosquitofish (*Gambusia holbrookii*), and banded sunfish (*Enneacanthus obesus*) (Palis 1996).

Larval habitat

Larval flatwoods salamanders occur in acidic (pH 3.6 to 5.6), tannin-stained ephemeral wetlands (swamps or graminoid-dominated depressions) that range in size from 0.02 to 9.5 ha (0.05 to 23.5 acres) and are usually ≤0.5 m (≤1.6 ft) (Palis 1996). The overstory is typically dominated by pond cypress (*Taxodium ascendens*), blackgum (*Nyssa sylvatica* var. *biflora*), and slash pine, but can also include red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), sweetbay (*Magnolia virginiana*), and loblolly bay (*Gordonia lasianthus*). Canopy coverage ranges from near zero to almost 100 percent. The mid-story, which is often very dense, is most often composed of young of the aforementioned species, myrtle-leaved holly (*Ilex myrtifolia*), Chapman's St. John's-wort (*Hypericum chapmanii*), sandweed (*H. fasciculatum*), titi (*Cyrilla racemiflora*), storax (*Styrax americana*), popash (*Fraxinus caroliniana*), sweet pepperbush (*Clethra alnifolia*), fetterbush (*Lyonia lucida*), vine-wicky (*Pieris phillyreifolius*), and bamboo-vine (*Smilax laurifolia*). Depending on closure of the canopy and midstory, the herbaceous ground-cover of breeding sites can range from about 5 percent to nearly 100 percent (Palis 1996). The groundcover is dominated by graminaceous species, including beakrushes (*Rhynchospora* spp.), sedges (*Carex* spp.), panic grasses (*Panicum* spp.), bluestems (*Andropogon* spp.), jointtails (*Manisuris* spp.), three-awned grass (*Aristida affinis*), plumegrass (*Erianthus giganteus*), nutrush (*Scleria baldwinii*), and yellow-eyed grasses (*Xyris* spp.).

Post-larval habitat

Post-larval flatwoods salamanders inhabit mesic longleaf pine-wiregrass (*Aristida stricta*) flatwoods and savannas. Crayfish burrows are probably often used as retreats (Neill 1951, Ashton 1992). The terrestrial habitat is best described as a topographically flat or slightly rolling wiregrass-dominated grassland having little to no midstory and an open overstory of widely scattered longleaf pine. Low-growing shrubs, such as saw palmetto (*Serenoa repens*), inkberry (*Ilex glabra*), and blueberries (*Vaccinium* spp.), co-exist with grasses and forbs in the groundcover. Groundcover plant diversity is usually very high. The underlying soil is typically poorly drained sand that becomes seasonally saturated. The "Flatwoods and Sandhills" Community Report (Harper et al., in preparation) provides a complete description of this community.

Slash pine flatwoods often are cited as the preferred terrestrial habitat of the flatwoods salamander (e.g., Conant and Collins 1991). This may be the result of an error made by Martof (1968) in which he referred to longleaf pine as slash pine. In addition, slash pine now dominates or co-occurs with longleaf pine in many pine flatwoods communities as a result of fire suppression and preferential harvest of longleaf pine (Avers and Bracy 1975). Historically, however, fire-tolerant longleaf pine dominated the flatwoods, whereas slash pine was confined principally to wetlands (Harper 1914, Avers and Bracy 1975).

Critical or essential habitat

High-quality occurrences include several wetlands within a matrix of pine flatwoods and savanna. Based on the maximum distance adults are known to travel between reproductive and nonreproductive habitat (1.7 km or 1.1 miles (Ashton 1992)), at least 10 km^2 (3.9 $miles^2$) of terrestrial habitat surrounding a breeding site is probably needed to sustain each breeding population. Long-term perpetuation of a viable population of flatwoods salamanders will presumably require protection of a larger area of terrestrial habitat encompassing a suite of alternative breeding sites (Travis 1994). A suite of wetlands guards against extirpation at any one breeding site, since animals can immigrate from nearby wetlands. The minimum viable population size needed to sustain a population of flatwoods salamanders long term is not known. Drift fence data at Eglin Air Force Base (AFB), Florida, suggest that breeding population sizes are low relative to other *Ambystoma* (Palis 1996). However, this may be a site-specific observation, as larger breeding migrations have been observed elsewhere in the species' range (R. Moulis, Personal Communication, 1995). Presently, there are no standards for assessing an occurrence based on the number of animals captured at a drift fence[1] or the number of larvae inhabiting a breeding site.

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[1] A drift fence with pitfall receptacles is a structure often used to capture reptiles and amphibians. The structure typically consists of fence material (e.g., aluminum flashing) partially buried in the ground in a linear fashion, with pitfall receptacles (e.g., 18.925-ℓ (5-gal) bucket, coffee can) buried flush with the ground and against the fence material.

Because flatwoods salamanders are sensitive to human-induced alteration of their habitat (Means et al. 1996), perpetuation of existing populations will require preservation of undisturbed mesic longleaf pine-wiregrass flatwoods and savannas and graminaceous ephemeral wetlands. Protection of terrestrial and aquatic habitats will require implementation of the steps outlined in the management section below.

Impacts and Cause of Decline

Flatwoods salamanders are threatened by habitat destruction throughout their range. Habitat is destroyed as a result of agricultural and silvicultural practices (e.g., clearcutting, mechanical site preparation), fire suppression, and residential and commercial development.

Fire suppression

At Eglin AFB, Florida, flatwoods salamander breeding sites that have been fire suppressed have become overgrown with Chapman's St. John's-wort. The subcanopy formed by dense stands of this plant could reduce the groundcover of herbaceous species in the wetlands and eliminate the preferred diurnal retreat of salamander larvae (Palis 1995a).

On Fort Stewart, Georgia, plowed firebreaks are detrimental to flatwoods salamander reproduction. These plowlines are often placed in the wetland ecotone (e.g., cypress/blackgum ponds occurring in upland ecosystems) and subsequently alter pond hydroperiods, provide connections with other wetland systems (which can introduce predatory fish), and alter/destroy the herbaceous component of pond margins. Some plowlines hold enough water to make them attractive to amphibians for egg-laying. However, these plowlines typically dry before the breeding ponds do, stranding the eggs or larvae before they reach metamorphosis (TNC 1995).

Silviculture

Available evidence suggests a dramatic decline in flatwoods salamander observations since the implementation of plantation forestry. Modern silvicultural methods often alter soil hydrology, suppress fire, shorten timber rotations, and replace widely spaced longleaf pine with dense plantations of slash, loblolly (*P. taeda*), or sand (*P. clausa*) pines. Loss of groundcover vegetation due to mechanical soil preparation, fire suppression, and shading of the slash pine overstory has been implicated in the decline of a flatwoods salamander population in north Florida (Means et al. 1996).

Means et al. (1996) suggested that local flatwoods salamander populations may be extirpated from areas that lose excessive amounts of native terrestrial groundcover. These losses may stem from mechanical site preparation of the soil, herbicide application,

fire suppression, rutting and soil compaction resulting from timber harvests during wet periods, or a combination of these impacts (Palis 1995a).

Herbicides and fertilization

The effect of herbicide or fertilization application on flatwoods salamanders is unknown. However, fertilization of plantations often results in eutrophication of wetlands, promoting algal blooms. Larval flatwoods salamanders have not been observed in algal-choked wetlands (Palis 1996).

Changes in hydrology

Ditching or berming of small, isolated pond-cypress wetlands, a common practice when establishing slash pine plantations on mesic sites, results in lowered water levels and shortened hydroperiods (Marois and Ewel 1983). These hydrologic perturbations could prevent successful reproduction by preventing egg inundation or stranding larvae before they are capable of metamorphosis. Altered hydrology, in association with fire exclusion, results in a shift in dominance from pond-cypress to broad-leaved hardwoods, which reduce herbaceous groundcover vegetation through shading (Marois and Ewel 1983). This may be detrimental to flatwoods salamanders since larvae take shelter in herbaceous vegetation during the day. Ephemeral pond-cypress depressions are sometimes converted into permanent water bodies, rendering them unsuitable for flatwoods salamander reproduction (Palis 1996). Off-road vehicles, plowlines, and illegal trash dumping threaten the integrity of some breeding sites at Eglin AFB (Palis 1995a).

Bait harvesting

Larvae are threatened in some wetlands by the harvest of crayfish as bait. Bait harvesters drag large hardware cloth buckets through inundated vegetation, dump the contents of the bucket on the ground, and then sort out the crayfish. Flatwoods salamander larvae taken in this manner are left to die or collected as bait (Palis 1996).

Military training (adapted from Trame, in preparation)

Mechanized training. Mechanized military training can alter natural plant communities through impacts to soils and, subsequently, cause soil erosion. Intense use of tactical land vehicles (both tracked and wheeled) can cause extensive soil disturbance. In flatwoods, this can lead to ponded areas and restricted subsurface water flow. Ruts provide new microenvironments that are drier or wetter than the natural moisture level, and this may allow invasion of the community by plants that otherwise would not occur. A population of flatwoods salamanders on Fort Stewart, Georgia, is threatened by tank traffic passing through wetlands and savannas (TNC 1995).

Bivouacs. Military bivouacs, which involve a combination of vehiclar and non-mechanized trampling, can be a major source of soil compaction and related impacts.

Even frequently used bivouac sites may retain groundcover and pine regeneration if the soils are resistant to compaction (A. Trame, Personal Communication, 1996). However, sustained high levels of trampling can ultimately eliminate vegetation.

Fertilization. Fertilizer that is used in erosion control projects on installations may significantly impact wetlands and pine plantations. The additional nutrients may move with the groundwater through sandy soils and enter adjacent wetlands used by breeding flatwoods salamanders.

Fire. Military training can impact native communities and threatened, endangered, and sensitive species (TES) by fragmenting the fuel sources needed to carry fire over large areas. Native groundcover, especially grasses, are essential fuel sources that allow large areas to burn. Bunchgrasses are often eliminated in bivouac sites, assembly areas, and tank-maneuver areas through direct destruction or soil compaction. Areas that do not burn undergo a change in species composition and become increasingly shaded through time, resulting in loss of the natural community.

The most potentially beneficial effect of military training activities is the reintroduction of fire resulting from activities such as live arms firing and use of incendiary devices. The frequency of ignition on military installations, especially in high hazard impact areas, often produces a fire regime over large areas at a frequency that resembles presettlement natural fire return intervals. This encourages a mosaic burn pattern and enhances conditions for the fire-adapted species, including those associated with flatwoods (Gulf Engineers and Consultants, Inc., and Geo-Marine 1994; LeBlond et al. 1994).

Management and Protection

Fire

Maintenance of intact mesic longleaf pine-wiregrass flatwoods and ephemeral wetlands by mimicking natural forces, such as lightning-season fire (from May to September), is the most appropriate form of management. The natural fire regime of flatwoods salamander habitats should be restored on sites where altered, and maintenance of a graminaceous ecotone and breeding site will require burning in the lightning-season when wetlands are dry or nearly dry (Huffman and Blanchard 1990). These fires would occur outside the aboveground activity period of the post-larval life stages of the flatwoods salamander (Palis 1997). To prevent a catastrophic fire in areas that have not been burned recently, a fuel-reduction winter fire may be necessary before reintroducting lightning-season fire (Palis 1995a). Adult salamanders likely would not be harmed by winter fires since they are typically in below-ground retreats away from the high temperatures of fire. Also, flatwoods salamanders typically move to and from ponds when conditions are wet and flatwoods typically would not burn (TNC 1995).

Forest management

On sites where timber extraction is practiced, several precautions should be taken to limit impacts to flatwoods salamanders. Tree harvest should be restricted to dry periods to prevent soil compaction and rutting. Clearcutting should be replaced with selective timber harvest and natural regeneration enhanced by fire, particularly lightning-season fire. If offsite species such as slash pine, loblolly pine, or sand pine have been planted, they should be removed and replaced with longleaf pine at naturally occurring densities. Removal of offsite pine species may be accomplished with prescribed fire or on more xeric sites, with a bush-hog during dry periods (Palis 1995a).

Management of groundcover

Little or no soil disturbances should occur within 2 km (1.2 miles) of known salamander breeding sites since flatwoods salamanders have been known to move $\leq$1.7 km (1.1 miles) from a breeding site (Ashton 1992). If a site supports mature, closed-canopy pine plantations, it should be thinned with as little disturbance as possible to the soil and remaining groundcover. If necessary, trees should only be harvested during dry periods, and mechanical preparation of the soil should be avoided. Palis (1995a) stated that, "Clearcutting, and the associated use of mechanical site preparation and artificial planting of trees at densities higher than found in nature, should be replaced with selective timber harvest and natural regeneration enhanced by fire, particularly lightning-season fire." Finally, native groundcover should be reseeded with seeds of native groundcover species (e.g., wiregrass), and these propagules should be collected from species growing locally on the same soils (Palis 1995a).

Wetland/upland ecotone

The natural hydrology of aquatic habitats should be restored on altered sites. The wetland/upland ecotone appears to be critical to successful flatwoods salamander reproduction. The herbaceous edge of this ecotone is often used for egg deposition, and larvae often seek refuge and forage in this area as well (Palis 1995a). Mechanical disturbance of the wetland-upland ecotone should be avoided, and the practice of encircling wetlands with plow lines should be abandoned. Berms should be removed and drainage ditches filled.

Species recovery

Flatwoods salamander recovery is directly linked to the ability to preserve existing habitat and restore degraded habitat. Given the drastic decline in the extent of longleaf pine-dominated communities (Ware et al. 1993), the elevation of flatwoods salamander populations above present levels is unlikely. Restoration of degraded mesic, seasonally inundated longleaf pine flatwoods and savannas has not been attempted and may only be feasible in cases where soil disturbance is minimal. The effectiveness of reintroducing flatwoods salamanders into areas where it has been extirpated is unknown.

Inventory and Monitoring

Census methods

Annual quantitative surveys of breeding sites are needed to assess variation in larval numbers among years. Despite recent surveys throughout the species' range, an incomplete understanding of the flatwoods salamander's present-day distribution still exists. Demographic data are needed to better understand the natural history, particularly factors that limit population size (e.g., egg, larval, and metamorph survivorship; competition with other species). Studies are urgently needed to determine terrestrial habitat use by flatwoods salamanders (Means et al. 1996).

Prior to initiation of field work, potential flatwoods salamander habitat can be delineated on 7.5-minute U.S. Geological Survey topographic maps, aerial photographs, and/or county soil surveys. To allow larvae to reach a readily sampled size, surveys can begin a month or more after known and potential breeding sites fill with water (Palis 1995a). Palis (1995a) stressed the importance of multiple-year surveys for assessing the presence or absence of flatwoods salamanders; because hydrologic conditions may differ among years, sites not used for breeding one year may be used the following year if suitable conditions exit.

An estimation of larval density can be obtained by walking with the aid of a flashlight along nocturnal transects. However, this technique is only applicable to wetlands having little herbaceous vegetation and relatively clear water. Minnow trapping with a Gee 6-mm wire mesh funnel trap has been used with limited success. Methods of quantifying larval sampling are described by Shaffer et al. (1994).

Monitoring

Drift fence monitoring programs should be implemented at various locations within the range of the flatwoods salamander at sites exhibiting varying degrees of human disturbance. The simplest and most inexpensive means of monitoring flatwoods salamanders is dip net surveys of larval habitat. A 4-mm mesh nylon dip net, manufactured by Mid-Lakes Corporation, Knoxville, TN (Net No. SH-2), has been successfully used for larval sampling throughout Florida (including Eglin AFB, Florida) (Palis 1995a). Larval surveys are most successful during the latter half of February and the first half of March, although sampling in other months may be as productive depending upon rainfall patterns and wetland hydrology. Larvae are most readily captured by sweeping a dip net through inundated graminaceous vegetation by day or night (Palis 1996). Several dip netting techniques will capture larvae. The net can be swept back and forth through inundated vegetation in a zig-zag pattern. A second method involves submerging the bag of the net adjacent to the vegetation to be sampled, agitating the vegetation by foot or hand toward the net, and then thrusting the net through the vegetation in the opposite direction. In addition, multiple parallel dip net sweeps can be made in the same direction. Because

flatwoods salamander larvae occur at low densities (Sekerak 1994), an average of 16 m^2 (172 ft^2) of habitat may need to be surveyed before capturing the first larva (Palis 1996).

The breeding population at a particular wetland can be monitored by the use of a drift fence and traps. To obtain an accurate estimate of the population size, the entire breeding site must be encircled with a drift fence. Drift fences with traps have proven to be excellent means of surveying amphibian movement into and out of breeding sites (Gibbons and Semlitsch 1981; Palis 1995a). On Eglin AFB, Florida, Palis (1995a) used 30.5-m (100-ft)-long by 0.9-m (2.9-ft)-high silt fences, and 15.25-m (50-ft)-long by 0.61-m (2-ft) aluminum flashing drift fences to monitor presence/absence of flatwoods salamanders. A 0.6-m (2-ft)-wide path was cut with mechanical weed-eaters around a breeding pond through the grass-dominated ecotone. A mechanical trencher was then used to excavate a 20-cm (8-in.)-deep, 10-cm (4-in.)-wide trench in the middle of the cleared path. The bottom 10 to 15 cm (4 to 6 in.) of the fence was buried in the soil, and the aboveground structure was supported by wooden stakes. Because the water table at flatwoods salamander breeding sites is high, aluminum window screen funnel traps are required. Drift fencing is most productive between October and December when flatwoods salamanders are at the surface moving to and from breeding sites (Palis 1997). Long-term drift fence studies are needed at several proximal sites to examine interpond salamander movement and to delineate the range of natural population fluctuations. The response of this species to human-induced habitat disturbance and altered fire regimes needs study.

References

Anderson, J. D., and G. K. Williamson. 1976. Terrestrial mode of reproduction in *Ambystoma cingulatum*. Herpetologica 32:214-221.

Ashton, R. E., Jr. 1992. Flatwoods Salamander. Pages 61-64 *In*: Rare and Endangered Biota of Florida, Vol. 3, Amphibians and Reptiles. Univ. Florida Press, Gainesville.

Avers, P. E., and K. C. Bracy. 1975. Soils and Physiography of the Osceola National Forest. USDA Forest Service, Unpubl. Rep.

Carr, A. F. 1940. A Contribution to the Herpetology of Florida. Univ. Florida Publ., Biol. Sci. Ser. 3:1-118.

Conant, R., and J. T. Collins. 1991. A Field Guide to Amphibians and Reptiles, Eastern and Central North America. Houghton Mifflin Co., Boston.

Gibbons, J. W., and R. D. Semlitsch. 1981. Terrestrial drift fences with pitfall traps: An effective technique for quantitative sampling of animal populations. Brimleyana 7:1-16.

Goin, C. J. 1950. A study of the salamander, *Ambystoma cingulatum*, with the description of a new subspecies. Ann. Carnegie Mus. 31:229-321.

Gulf Engineers and Consultants, Inc., and Geo-Marine, Inc. 1994. Rare, threatened and endangered species survey and their habitat at Fort Benning, Georgia. Contract No. DACW21-89-0016. Final Report. Baton Rouge, Louisiana.

Hardy, J. D., Jr., and J. Olmon. 1974. Restriction of the range of the frosted salamander, *Ambystoma cingulatum,* based on a comparison of the larvae of *Ambystoma cingulatum* and *Ambystoma mabeei*. Herpetologica 30:156-160.

Harper, R. M. 1914. Geography and vegetation of northern Florida. Florida Geol. Survey Sixth Annu. Report: 163-451.

Harper, M. G., R. A. Fischer, A. M. Trame, and C. O. Martin. Plant Community Management Report: Southern Pine Woodlands. Technical Report in preparation. U.S. Army Construction Engineering Research Laboratories, Champaign, Illinois.

Huffman, J. M, and S. W. Blanchard. 1990. Changes in woody vegetation in Florida dry prairie and wetlands during a period of fire exclusion, and after dry-growing-season fire. Pages 75-83 *In*: Fire and the Environment: Ecological and Cultural Perspectives. Gen. Tech. Rep. SE-69. USDA For. Serv., SE For. Exp. Station, Asheville, North Carolina.

Knight, G. R., L. G. Chafin, J. Amoroso, D. B. Means, and R. West. 1994. Final report: Biological survey of Tyndall Air Force Base. Florida Natural Areas Inventory, Tallahassee, Florida.

LeBlond, R. J., J. O. Fussell, and A. L. Braswell. 1994. Inventory of the rare species, natural communities, and critical areas of the Camp LeJeune Marine Corps Base, North Carolina. North Carolina Nat. Heritage Prog., Div. Parks and Rec., Dept. Environ., Health, and Nat. Res., Raleigh, North Carolina.

Marois, K. C., and K. C. Ewel. 1983. Natural and management-related variation in cypress domes. Forest Science 29:627-640.

Martof, B. S. 1968. *Ambystoma cingulatum*. Catalog of Am. Amphibians. Rep. 57.1-57.2.

Means, D. B. 1972. Notes on the autumn breeding biology of *Ambystoma cingulatum* (Cope) (Amphibia: Urodela: Ambystomatidae). ASB Bull. 19:84.

Means, D. B. 1986. Special Concern: Flatwoods Salamander. Pages 42-43 *In*: R. H. Mount, ed.. Vertebrate Animals of Alabama in Need of Special Attention. Alabama Agric. Exp. Station, Auburn Univ., Alabama.

Means, D. B., J. G. Palis, and M. Baggett. 1996. Effects of slash pine silviculture on a Florida population of flatwoods salamanders. Conserv. Biol. 10:426-437.

Mount, R. H. 1975. The Reptiles and Amphibians of Alabama. Auburn Printing Co., Auburn, Alabama.

Neill, W. T. 1951. Notes on the role of crawfishes in the ecology of reptiles, amphibians, and fishes. Ecology 32:764-766.

Palis, J. G. 1995a. Final Report: Distribution and breeding biology of the flatwoods salamander (*Ambystoma cingulatum*) and gopher frog (*Rana capito*) on Eglin Air Force Base, Florida. Florida Natural Areas Inventory, Tallahassee, Florida.

Palis, J. G. 1995b. Larval growth, development, and metamorphosis of *Ambystoma cingulatum* on the Gulf Coastal Plain of Florida. Florida Scientist 58:352-358.

Palis, J. G. 1996. Element Stewardship Abstract for *Ambystoma cingulatum*- flatwoods salamander. Natural Areas Journal 16:49-54.

Palis, J. G. 1997. Breeding migration of *Ambystoma cingulatum* in Florida. Journal of Herpetology. In Press.

Sekerak, C. M. 1994. Vegetation and aquatic vertebrate and macroinvertebrate assemblages in flatwoods salamander breeding ponds in the Apalachicola National Forest. M.S. Thesis, Univ. of Florida, Gainesville.

Shaffer, H. B., R. A. Alford, B. D. Woodward, S. J. Richards, R. G. Alting, and C. Gascon. 1994. Quantitative sampling of amphibian larvae. Pages 130-141 *In*: W. R. Heyer, M. A. Donnely, R. W. McDiarmid, L. C. Hayek and M. S. Foster, eds. Measuring and Monitoring Biological Diversity, Standard Methods for Amphibians. Smithsonian Institution Press, Washington.

The Nature Conservancy. 1995. Fort Stewart inventory, Final Rep. U.S. Dep. of Defense, Dep. of the Army, Headquarters 24th Mechanized Div., Fort Stewart, Georgia.

Trame, A. M. Potential military impacts to selected plant communities in the southeastern U.S. U.S. Army Construction Engineering Research Laboratories, Technical Report in preparation.

Travis, J. T. 1994. Calibrating our expectations in studying amphibian populations. Herpetologica 50:104-108.

Ware, S., C. Frost, and P. D. Doerr. 1993. Southern mixed hardwood forest: the former longleaf pine forest. Pages 447-493 *In*: W. H. Martin, S. G. Boyce, and A. C. Echternacht, eds. Biodiversity of the Southeastern United States, Lowland Terrestrial Communities. John Wiley and Sons, Inc., New York.

Personal Communications

Bennett. S. 1995. Coordinator, South Carolina Heritage Trust, South Carolina Wildlife and Marine Resources Department, PO Box 167, Columbia, South Carolina 29202; 803-743-3893.

Godwin, James. 1995. Zoologist, Alabama Natural Heritage Program, Huntingdon College, Massey Hall, 1500 E. Fairview Avenue, Montgomery, Alabama, 36106; 334-834-4519.

Moler, Paul. 1995. Biological Administrator, Florida Game and Fresh Water Fish Comm., Wildlife Research Lab., 4005 South Main St., Gainesville, FL 32601-9099. 352-955-2230.

Moulis, R. 1994. 681 Fort Argyle Road, Savannah, Georgia 31419; 912-925-9461.

Stevenson, Dirk. 1996. Biologist, Fort Stewart, Georgia. PO Box 1428, 202 Church Street, Pembroke, Georgia 31321; 912-767-2584.

Trame, Ann-Marie. 1996. Ecologist, U.S. Army Construction Engineering Research Laboratories, Champaign, IL, Natural Resources Division, 2902 Farber Dr., Champaign, IL 61826. 217-398-5498; *a-trame@cecer.army.mil.*

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13. ABSTRACT *(Maximum 200 words)*

The flatwoods salamander (*Ambystoma cingulatum*) is a rare salamander of the Southeast that is a former candidate species for listing as Threatened or Endangered by the U.S. Fish and Wildlife Service. The species inhabits the lower Southeastern Coastal Plain from southern South Carolina to northern Florida, and westward through Georgia to extreme southwestern Alabama. Preferred habitat includes fire-maintained, open-canopied longleaf pine and slash-pine flatwoods depressions, swamps, roadside ditches, and borrow pits. The flatwoods salamander has been documented on several military installations in Georgia and Florida. This report is one of a series of "Species Profiles" being developed for threatened, endangered, and sensitive species inhabiting southeastern United States plant communities. The work is being conducted as part of the Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP). The report is designed to supplement information provided in plant community management reports for major United States plant communities found on military installations. Information provided on the flatwoods salamander includes status, life history and ecology, habitat requirements, impacts and cause of decline, management and protection, and inventory and monitoring.

14. SUBJECT TERMS

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